Salvador Morales-Conde

Laparoscopic Ventral Hernia Repair

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Salvador Morales-Conde (EDITOR)
Laparoscopic Surgery Division
University Hospital Virgen Macarena
Sevilla
Spain

Salvador Morales-Méndez (CO-EDITOR)
Chief of the General, Digestive and Laparoscopic Surgery Unit
University Hospital Virgen del Rocio
Sevilla
Spain

Dedication

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2. The voluntary activation of the oblique loops, consisting of the contralateral external and internal oblique muscles tenses up the whole abdominal wall and allows specific rotational movements.

Mechanics

Tension and tensile strength

Whereas tension strength as a sort of pressure means force per cm², tensile strength is defined as force per cm and thus reflects the stability of the anatomic structures in a more suitable way. According to Tauber and Seidel (24) the tensile strength of the rectus sheath measured horizontally is about 70 to 80 N/cm, but is reduced to ¼ vertically. Because the force for tearing out the seam is only ⅓ to ¼ of the tensile strength of the tissue as measured by tearing out stripes, there results an effective load-bearing capacity of about 10 to 20 N/cm.

The mechanical requirements for any repair largely depend on the intraabdominal pressure. This ranges from 0,2 kPa in rest to a maximum pressure of almost 20 kPa (= 150 mm Hg) (8). Already at comparatively low pressure values of 1,3 kPa a considerable reduction of the blood supply within the abdominal wall to 42% has been seen (21). Transgastric measurements reveal a pressure of 11 to 15 kPa in erect position, changing from 10 - 12 kPa during flexion to 8.5 - 10 kPa at maximum extension, mainly corresponding to alterations in the activity of the transverse muscles (5). However, the maximum intraabdominal pressure can be assumed to be less than 20 kPa.

According to the formula of LaPlace, assuming a circumference of 100 cm, a maximum pressure of 20 kPa, and a thickness of the layer of 0,08 cm, a tension strength of about 200 N/cm² results.

La Place: *tension* strength $\tau = P * r / 2s$ (N/cm²)

P = pressure, r = radius, s = thickness of muscle-layer

Though usually done (8) equating this tension strength to the tensile strength required for repair is not suitable. Instead, to estimate the necessary strength the human body can be regarded as a thin-walled hollow cylinder: by multiplying the supposed contact area of 8 cm² with the value of the tension strength at a circumference of 100 cm, a total force of 1600 N results. Division by the circumference allows to omit the vague size of the layer and results in a for-mula where the tensile strength depends only on the intraabdominal pressure and the diameter.

$F = P * d/4$ (N/cm)

d = diameter, P = pressure, F= force per cm circumference

Assuming a circumference of 100 cm and a maximum pressure of 20 kPa, theoretically a maximum tensile strength of about 16 N/cm results for humans (9) (fig. 8).

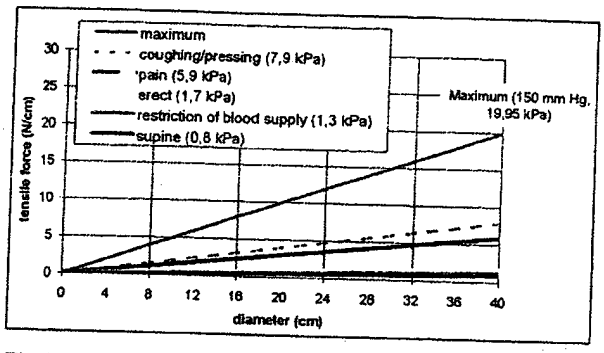

Fig. 8. Calculated tensile strength in relation to the diameter.

Apart from extreme strain, physiologically we have to deal with rather low tensile forces of 1-4 N/cm. These calculated data are in accordance with experimental studies where the tensile forces of applied sutures are recorded. All reports, Lipton et al. (11) for a Bassini repair as well as Read and McLeod (19) for a McVay, Calcagno and Wantz (4) for a Shouldice Repair, or Peiper et al.'s investigation of the groin's ability to withstand stress in humans (16), measured forces of far less than 10 N/cm. Thus we can conclude, that physiologically the required tensile strength even at maximum strain does not exceed the calculated value of 16 N/cm as an upper limit.

In regard to the widespread use of various mesh materials for the repair of incisional hernias it has to be mentioned that most of these materials exceed this range and thus appear to be considerably oversized (fig. 9).

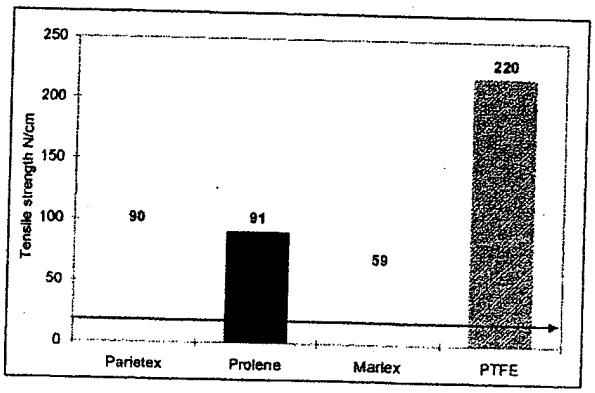

Fig. 9. Tensile strength of currently available mesh materials, Æ maximum tensile strength of 16 N/cm.

Elasticity

It is mainly the flexibility of the abdominal wall, whose impairment can cause severe complaints of the patients. It is well known that each laparotomy is followed by considerable pain together with a marked restriction of abdominal